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IV.

CONTRIBUTIONS FROM THE CRYPTOGAMIC LABORATORY OF HARVARD UNIVERSITY.

XII. — CONCERNING THE STRUCTURE AND DEVELOPMENT OF TUOMEYA FLUVIATILIS, HARV.*

By William Albert Setchell.

Presented by W. G. Farlow, April 9, 1890.

The generic name *Tuomeya*, bestowed by Harvey upon a rare and curious fresh-water alga sent him from the United States, commemorates a diligent collector and contributor to the work on the Nereis, Professor Tuomey of Alabama. Harvey mentions that *Tuomeya fluviatilis*, as the species was named, had been collected in a river in Alabama by Professor Tuomey, and near Fredericksburg, Virginia, by Professor J. W. Bailey. In his general remarks on the suborder *Batrachospermeæ*, however, Harvey mentions New York and Alabama as "distant localities" in which the species had been found. As New York does not appear in the formal list of localities under the species, we may infer that the reference here is due to a slip on the part of Harvey's memory. He was doubtless thinking of Bailey's plant and forgot, for the moment, that this had been collected in Virginia, and not near Bailey's home in New York.

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* The following statement should be made with regard to the name of the alga whose structure is described in the present paper. The specimens collected by Professor Tuomey were sent originally to Harvey, who described them under the name of *Tuomeya fluviatilis* in the third part of his *Nereis Boreali Americana*, which was accepted for publication in September, 1857, and issued in March, 1858. Meanwhile Harvey had apparently sent a specimen of his plant to Kuetzing, who described and figured it, under the name of *Baileya Americana*, in his *Tabulæ Phycologicæ*, VII. 35, Plate LXXXVII. Fig. 3, of which the title-page bears the date 1857. The generic name given by Kuetzing cannot stand, since there was a genus of *Compositæ* of the same name described by A. Gray in 1848. Whether the specific name of Kuetzing should have preference over that of Harvey may be questioned, considering that, while the date of Volume VII. of the *Tabulæ* is given as 1857, it may not have been distributed until early in 1858; so that the date of Kuetzing's publication and that of Harvey's, so far as the botanical public were concerned, were almost identical. Certainly Harvey could have had no knowledge that Kuetzing was about to describe the specimens originally sent to himself, and, if there seem to be any doubt as to date of publication, under the circumstances Harvey should have the benefit of the doubt. — W. G. F.

Many students of American fresh-water algæ since Harvey's time have searched diligently in the hope of rediscovering this most interesting species, but without success. For nearly forty years now, no authentic report of the finding of *Tuomeya fluviatilis* has been published. It is, then, a great pleasure to be able to announce that Mr. Isaac Holden, a diligent student of our American algæ, has found this long lost plant in some quantity in a brook near Bridgeport, Conn. The date of Mr. Holden's first discovery was December 16, 1888. Since then it has been found in several places. Mr. Holden has found it in several other localities near Bridgeport, and at Mount Desert Island on the coast of Maine, nearly three hundred miles distant from Bridgeport. Mr. E. B. Harger also has found it in large quantity in a brook near his home in Oxford, Conn. These several localities added to the two given by Harvey show that the range of *Tuomeya fluviatilis* extends along our whole Atlantic border, from Maine to Alabama, a distance of about twelve hundred miles. We may also expect that it will be found farther inland.*

It will be best, perhaps, before proceeding farther, to give the reasons for considering that our plant is the genuine *Tuomeya fluviatilis* of Harvey. It was first compared with the description which Harvey gives in the Nereis, and was found to agree with it in every respect. Harvey's description, indeed, is so full and so accurate as to leave little room for doubt. But through the kindness of Professor W. G. Farlow of Harvard University, I have been able to examine an authentic specimen, which had been presented to him by Professor

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* As the preceding communication was about to go to press, I received information that *Tuomeya fluviatilis* had been found in another locality in New England. On April 3, 1890, Mr. A. P. D. Piguet of Jamaica Plain, Mass., found specimens of it in the town of Sharon, about fifteen miles south from Boston. This locality, the fourth in New England, is situated very nearly halfway between those at Oxford and Bridgeport in Southwestern Connecticut and the one at Mount Desert, Me. I was able, through the kindness of Mr. Piguet, to examine this new locality. The *Tuomeya* was growing in some abundance in a narrow, rocky brook, just below the dam of a small mill-pond. At the place where the plants were growing the current was very rapid. On the same stones with the *Tuomeya* were growing a large *Batrachospermum*, probably *B. Boryanum*, Sirdt., and tufts of a small reddish *Chantransia*, which seems to agree with *C. Hermanni*, Desv. In a few cases specimens of these plants were growing on the specimens of *Tuomeya*.

E. P. Wright, Curator of the Harveyan Herbarium at Trinity College, Dublin. With this specimen, our plant was carefully and critically compared, and was found to agree with it in every point of structure and habit. There can be no reasonable doubt that the specimens received from Messrs. Holden and Harger belong to the *Tuomeya fluviatilis* of the Nereis.

The systematic position of *Tuomeya* is a matter of considerable interest and importance. Harvey says, on page 62 of the Nereis: "The plants referred to this order (*Batrachospermeæ*) naturally group themselves into two suborders, distinguished from each other by the habit of the frond, but closely related in structure and fructification, and as it seems to me inseparably connected by the genus *Tuomeya*, which unites in itself the characters of the seemingly so dissimilar genera *Batrachospermum* and *Lemanea*." An exact knowledge of the relation which *Tuomeya* bears to *Lemanea* and *Batrachospermum* respectively, requires a careful comparison of the details of the structure and development to be found in these three genera. As Harvey had only a few dried specimens of *Tuomeya* at his disposal, he did not undertake to do this. Indeed, he remarks that he had not even ventured to make a drawing from them. Dried specimens, as far as my experience goes, are peculiarly unsuitable for study, as the various cells do not recover their original size and shape at all well. The manipulation of plants which have been long dried is a difficult and unprofitable task. Specimens which have been preserved in weak alcohol (of a strength of about fifty per cent) are much better for the purpose, but the hardening of the elements produced by the alcohol imparts a rigidity and a brittleness which are detrimental to obtaining the best results. Fresh material is readily prepared for the microscope, and shows the details both of structure and development most satisfactorily. The work whose results are summarized below has been done entirely upon the living specimens, and the author has thus been able to obtain a more complete knowledge of the life history of *Tuomeya* than would have been possible under any other circumstances. Through the kindness of Mr. Holden, he has been supplied at frequent intervals with fresh specimens, not only of *Tuomeya*, but of various species of *Lemanea* and *Batrachospermum* as well. With such facilities, it has been possible to compare the structure and development in these genera, point for point, and to determine with a certain degree of definiteness the exact relation existing between them.

The method of investigation has been a comparatively simple one.

If a small portion of the upper part of a branch be gently crushed between a slide and a cover-glass, one can readily see all the principal stages in the growth from the apical cell, even to the production of the complexity of the adult frond. By a judicious agitation of the cover-glass by tapping gently, the various sets of cells may be made to separate in such a fashion as to show all the lesser details. The old frond is so dense as to be crushed with some difficulty, and in the process the relations are often more or less obscured. Therefore sections are a necessary aid to understanding the structure of such portions, but can be made in any direction with considerable ease. During the investigation of the development of the frond, the sexual organs and developing fruit were discovered and carefully studied. By this, we are enabled to make our comparison more thorough and more exact.

Tuomeya fluviatilis is found in brooks or small streams, and seems to prefer those windings of the course or declivities in the bed where the current is accelerated. It grows for the most part on smooth stones or rocks, clustered together in considerable numbers. In a few cases, Mr. Holden has found it growing upon grasses. When kept in the house, *Tuomeya* generally flourishes well, if the temperature be not too high, and if it has an occasional supply of fresh water. It often puts forth new branches under such circumstances, and one lot even produced the sexual organs.

In regard to the general habit of the plant, Harvey's description can hardly be improved upon. It scarcely ever reaches a height of over two inches (5 cm.), is pyramidal or irregularly conical in general outline, and decidedly bushy (cf. Fig. 1). The plant is comparatively rigid, and does not collapse on being removed from the water. In this respect, it differs much from the larger specimens of *Batrachospermum*, which it greatly resembles in size, color, and manner of growth, and with which it very frequently grows. Indeed, it is often difficult to tell *Tuomeya*, when growing, from one of these larger *Batrachosperma*, unless one touches the specimen or takes it from the water. The *Tuomeya* then remains firm and retains its shape, while the *Batrachospermum* utterly collapses and becomes a shapeless gelatinous mass. The younger branches of *Tuomeya*, however, are often very slender, and then generally droop considerably on being withdrawn from the water, but to no such extent as is characteristic of the *Batrachosperma*. When dried, specimens of *Tuomeya* seem to be decidedly cartilaginous, resembling in this respect specimens of *Ahnfeldtia plicata*. They do not adhere closely to paper, even after being subjected to a considerable pressure. In this respect, as well as in all others depending upon consistency, *Tuomeya* resembles more closely the rigid *Lemanea* rather than the gelatinous *Batrachospermum.*

From a discoidal base, which is often three sixteenths of an inch (5 mm.) in diameter, there generally arises a stout stem, which is soon lost above in the numerous long main branches. This stem often reaches a diameter of a little over a sixteenth of an inch (2 mm.). Harvey's expression, "Frond . . . scarcely as thick as a hog's bristle," refers of course only to the condition in the dried specimens from which his description was drawn.

The branching is monopodial, and is quite irregular, being, as Harvey says, "alternate or secund, scattered or crowded." The branches, which are long and somewhat flexuous, are from five to six times branched. The axils are usually patent, and the ultimate ramuli are rather numerous, comparatively short, and more or less subulate. According to the description in the Nereis, these ultimate ramuli are "slightly constricted at the insertions, and taper to an obtuse point," but these characters are not always prominent in the dried specimens in my possession. At the very base the stem and the main branches are irregularly cylindrical, while farther up the branches are generally nodose, which appearance is usually rendered more conspicuous in drying. Toward the tip the branches are quite regularly cylindrical, and at the very apex are bluntly conical, or at times acute.

When the tip of a branch or branchlet is examined with a power of about five hundred diameters, it is seen to be composed of a cluster of more or less erect microscopic filaments, from the centre of which projects the short, stout main filament to a height of from 16 to 20 μ (cf. Fig. 2). This main filament is composed of a single row of cells placed end to end, and terminates in a cell which is in a state of active growth. This apical cell is, in most cases, bluntly conical in shape, and measures from 6 to 8 μ in height, and from 4 to 6 μ in basal diameter. Lining the external wall is a thick, dense chromatophore, but the contents of the central portion, as seen in a median optical section, are colorless. From the base of the apical cell, new cells are cut off by horizontal partitions, and the cells thus cut off are in shape discoidal, measuring usually only 2 to 3 μ in height, while the diameter equals 10 to 12 μ. The second or third cell from the tip generally has a small lateral protuberance, or perhaps two or three protuberances side by side, covering only a small fraction of the external wall. The next two or three cells lower down also usually have protuberances of the same size and shape, and the protuberances of all these cells are usually in the same vertical row or rows. This gives the protruding filament, when seen in side view, the appearance of being straight and unmodified along one margin, but more or less irregularly nodose along the other (cf. Figs. 3 and 11).

As the protuberances increase in size and begin to elongate, they become separated from the parent cell by a tangential wall. These side cells form two or three new cells at their tips by a sort of budding process. Two or three small papillæ make their appearance on the free end of the cell, gradually increase in size, become constricted, and are finally cut off by a division wall (cf. Fig. 4). Each of the new cells proceeds to grow in a similar fashion, and so we soon have developed from each protuberance a di- or trichotomously branched ramellus, which spreads out in all directions from the point of attachment. During this process, new protuberances have been developing on the same cells with those first formed, and have also been growing out into ramelli, so that finally each cell of the main filament has several (in most cases four) ramelli attached to it. As the ramelli elongate, the basal cells increase in size, and as their basal diameter increases they occupy more and more of the circumference of the parent cell, until, when well developed, they completely encircle it. The four ramelli then form a whorl, each ramellus being situated at right angles to its neighbor.

During the process of the formation of the ramelli, the axis has been actively growing, new cells have been forming at the tip, and the older cells of the axis have been elongating upwards. As these cells elongate, the whorls of ramelli remain at the very uppermost portion. As the main cells elongate, they also become somewhat swollen, and hence moniliform, there being a constriction formed at the junction of two cells. Consequently the basal cells of the ramelli, since they are situated on the extreme upper portion, are attached to one side of this constriction. As they enlarge, they necessarily touch the other side of the constriction with a portion of the lateral wall, and grow to it. In this way the basal cells of the ramelli become attached to two cells of the axis. The point where two axial cells join may conveniently be called the node, and the axial cells themselves may be termed the internodes.

The ramelli undergo several important changes as they develop. At first, the cells composing them are all small and nearly of the same size and shape. They are also provided with large and solid chromatophores (cf. Fig. 6). As the ramellus elongates, the proximal cells gradually become somewhat swollen. They are finally broadly spheroidal in shape, filled with a reticulated mass of protoplasm and with a few small lenticular-shaped chromatophores (cf. Fig. 7). This causes them to appear as large and transparent sacs, forming a stratum adjoining the axis. As we go toward the outer end of one of the more adult ramelli, the cells grow smaller, they possess more abundant and larger chromatophores, and hence the outer strata of cells appear denser and darker colored. The transition from one stratum to the other is in most cases decidedly abrupt. This appearance of an inner transparent layer, sharply defined from an outer dark layer, is visible to the naked eye. In rather old portions of the plant, the very end cells, which in such places are of course very numerous, become elongated and cylindrical, and so appear to clothe the frond with a layer of fine filaments.

During their growth, the branchlets of the ramelli intertwine with the branchlets of the ramelli both of the same and of adjacent whorls, and this takes place to such an extent as to form a dense mass of cells about the axis, separated from it by a small space, and connected with it only at the nodes by the basal cells of the ramelli. We have thus a hollow cylindrical frond formed about the axis, composed of two sets of cells, much resembling the structure in the fronds of certain species of *Lemanea*. When a portion of such a frond is crushed, the peripheral wall of the cylinder separates, and leaves the axis in pieces of considerable size.

But before this cylinder is fully formed, and even as soon as the internodal cells have elongated sufficiently to separate well the whorls of ramelli, another complication of the structure arises. Filaments are given off from the basal cells of the ramelli, which differ decidedly in appearance from the ramelli arising from the same cells. While the ramelli are more or less moniliform and regularly di- or trichotomously branched, these filaments are uniformly cylindrical, and for the greater part simple. While the ramelli grow outwards and away from the axis, these new secondary filaments have a downward course, and apply themselves closely to the axis, twining about it in such a manner as finally entirely to hide the cells of which it is composed. Some of these secondary filaments may originate from the more distal cells of a ramellus, and in the older portions, many of them thus arising may grow obliquely outwards, as well as downwards. In very old stems, it frequently happens that several of these filaments, intertwined so as to form a strand, proceed obliquely downwards to the surface of the frond, and even beyond it. Some were found to project beyond the surface of the frond to a distance of over a quarter of an inch (about 6 mm.). These strands appear to be of an adventitious nature, and may perhaps become attached to some support and grow into new plants. The filaments have the power of developing into branches, and this fact leads me to think that new plants may be produced from the strands. I have had little opportunity of making observations on growing plants, and consequently have not been able to verify this supposition. But the plants of *Tuomeya* are accustomed to grow in small bunches, the individual plants of which seem to be attached to one another by stolon-like stems. Such outgrowths are not uncommon both in *Lemanea* and *Batrachospermum.*

In the older portions, the walls of these secondary filaments become thickened, and the filaments themselves become so numerous as completely to fill up the space between the axis and the inner portion of the cylinder mentioned above. Thus we have formed a comparatively solid frond. In Figure 10 is given a camera drawing of a portion of a section across such a frond. At *a* is the cross-section of the internodal cell, which occupies the centre of the section. Around *a* are seen the cross and oblique sections of the cluster of secondary filaments, here labelled *b*, which are entwined about *a*. At *c* is represented the "inner peripheric stratum" of Harvey, which can be seen to be portions of a ramellus, whose next portion, *d*, shows smaller elements more densely compacted together. The cells of the two outer rows (*e*) are elongated and cylindrical, and form the "coat of moniliform filaments" which Harvey refers to as the "second peripheric stratum." The drawing was made from a section, which, while fresh, was carefully compared with a similar section from Harvey's plant, and which was found to agree with it in every respect.

We are now ready to compare the structure of the frond of *Tuomeya* with that of *Lemanea* and *Batrachospermum.* In all three genera, the growth is from an apical cell. In *Tuomeya*, as we have seen, this is borne on a protruding filament, which has the young ramelli clustered about its base in the form of microscopic filaments. The same is true of *Batrachospermum*, in which the first stages of growth from the apical cell are almost identical in every respect with those of *Tuomeya. Lemanea* has apparently an entirely different mode of growth, although on careful study it is seen to be in accordance with the same plan. A filament of *Lemanea* ends in a single row of two or three cells, and the first lateral cells are divided off in the same order and in the same directions as in *Tuomeya* and *Batrachospermum*. But in *Lemanea* these lateral cells do not grow out into distinct and separate ramelli, but remain as members of a solid tissue which finally develops into the tubular frond characteristic of *Lemanea*. At the tips, then, of the branches and branchlets, the frond of *Tuomeya* is essentially like that of *Batrachospermum*, and unlike that of *Lemanea*. But its adult structure is just the opposite. *Batrachospermum* always retains the whorls, distinct and evident, and never compacted into a structure resembling a cortex. *Tuomeya*, on the contrary, as we have seen, by the dense growth of the ramelli and the intertwining of their branchlets produces at a comparatively early period a hollow and cylindrical frond, very much resembling that of a *Lemanea*. It lacks completely, however, the highly specialized lateral tubes so characteristic of that genus.

The growth of the secondary filaments in *Tuomeya* agrees with that of the secondary filaments in *Lemanea*. In *Batrachospermum* the secondary "corticating" filaments frequently branch in many species, and the branches resemble very closely those of the ramelli; but in *Tuomeya* and *Lemanea* they branch only at rare intervals, and, becoming very much thickened, materially increase the rigidity of the axis. The secondary filaments in *Tuomeya*, however, are not so completely modified as those of *Lemanea*. They retain some active vegetative functions, and have some special duties, as will be seen later.

In the younger portions of a frond of *Tuomeya*, the branches originate in a uniform manner, but in an irregular sequence. Here a branch usually takes the place of a ramellus, or of some portion of a ramellus. The first evidence we have that a branch is about to be formed is the appearance, as one of the members of a whorl, of a short filament, resembling the apical protruding filament of the tip of a branch, such as is mentioned above. This short filament increases in length, and soon has the protuberances along one side which are to grow out into the ramelli. In the forming branches, the protuberances are usually borne along the lower surface (cf. Fig. 5). In the older portions, the branches originate in a somewhat different fashion. A filament, resembling one of the secondary filaments, grows out in more or less of a horizontal direction, and when about to protrude beyond the surface of the frond begins to develop in the same fashion as a young branch (cf. Fig. 11). Young branches may also take their origin from the more distal cells of a ramellus.

Whenever the tip of a branch is injured, and its apical growth consequently checked, there is always an active production of branchlets in the immediate vicinity of the injury, so as to form a fasciculate cluster of branchlets at the tip. The same thing occurs also in a very striking fashion in *Lemanea*, as well as in *Batrachospermum*. The great facility with which branches may be put forth from any portion of the frond is a very noticeable feature in *Tuomeya*.

In manner of branching, which has much to do with general habit, *Tuomeya* follows *Batrachospermum* more closely than it does *Lemanea*. *Lemanea*, when it does branch frequently (e. g. *L. fucina*, Bory.), branches in a comparatively regular fashion, and the branches are generally alternate or nearly opposite. *Batrachosphermum*, however, branches very capriciously, and is followed in this by *Tuomeya*.

Unfortunately the germination of the spores has not been seen, nor has the opportunity for examining very young plants been given. The examination, early in September, of a few young plants, brought in on the stones to which they were attached, showed what appeared to be a basal layer of cells, whence arose a small turf of short unbranched filaments of a single row of cells each, at whose tips were somewhat swollen cells with decidedly granular contents. These turfs resembled in color and size the basal tufts about a large *Batrachospermum*, appearing to be *B. cœrulescens*, (Bory) Sirdt., which grew on the same stones, but differed in being unbranched, and in possessing the swollen tips to the filaments. These swollen bodies seemed to be very much like the sporules of the *Chantransia*-form of *Batrachospermum* as described by Sirodot. However this may be, it seems very likely that this turf of filaments may be a provision for the production of new plants when the old ones are torn away from it by floating branches, or by ice, or by sand in the current, all of which are active agents in such work, according to Mr. Holden's frequent experience.

The sexual organs and fruit were most diligently sought, both by Mr. Holden and myself, through each successive gathering. We did not however discover them until about the middle of October, but they have since occurred in some abundance. Both the antheridia and the procarps are found on the same plant, but are generally borne on separate portions of the frond. Both kinds of organs develop indifferently on any part of the plant, being found in the older portions as well as in the younger.

The branches which bear the antheridia arise at the nodes, either from the basal cells of the ramelli or from cells near these. These branches then either pass out horizontally to the surface of the frond, or else, descending through an internode to the next node below, there change their course and proceed out to the surface. Occasionally some of them grow obliquely downwards and outwards, but this method is not a common one. The branches are generally very numerous at a node, and form a dense ring surrounding it.

The antheridial branches are cylindrical, and at first unbranched. At the ends, which are situated at or just beneath the surface of the frond, they are two or three times branched in a corymbosely dichotomous fashion. They are composed of cylindrical cells, two to four times as long as broad, and resemble in general appearance the secondary filaments described above. The contents of the cells, however, are less decidedly green, being more of a bluish-gray color, more homogeneous and granular, and containing no conspicuous chromatophores (cf. Figs. 21 and 22).

The antheridia are borne at the tips of the branches, are spheroidal in shape, of an opaline tint, and with granular contents. In the centre is a large spot of greater refractive properties than the rest of the contents. On being liberated from the antheridium, the single antherozoid is, for a short time at least, of an irregular shape, and has a slight amœboid motion, but it soon becomes globular and motionless. After the antherozoid has been discharged, the basidial cell may grow through into the empty sac of the antheridium and produce there a new antheridium. One frequently finds the antheridium enclosed in two or three ruptured sacs, showing that the process may be repeated several times. A stage of this process is illustrated in Figure 22.

The antheridia in shape, color, and character of contents exactly agree with those of *Batrachospermum*, and in these respects differ from those of *Lemanea*. The antheridia of *Batrachospermum*, however, are borne singly, or in twos or threes, on various cells of the unmodified ramelli. In *Lemanea*, on the contrary, they are all borne at the nodes, and are situated at the tips of a special layer of dichotomous, short filaments. In this, then, as will be seen from the above, *Tuomeya* differs decidedly from *Batrachospermum* and approaches *Lemanea*. The necessity for having the antheridia situated in the external layer in *Tuomeya*, as well as in *Lemanea*, is probably to be found in the possession of a solid frond by both of these genera. If borne in the interior of such a frond, the antherozoids would have difficulty in being carried from plant to plant by the currents. In *Batrachospermum* the difficulty is not so great, yet even here the antheridia are borne on the outer joints of the ramelli rather than on the inner ones. As far, then, as the structure and position of the antheridia are concerned, *Tuomeya* is rather more like *Lemanea* than it is like *Batrachospermum.*

The female organs are borne upon especially modified procarpic branches. In the axil of one of the ramelli — generally in the younger, growing portion of a frond, but very frequently also in the maturer, older parts of the same frond — arise one or more short branchlets of an appearance very different from any of the other outgrowths from the axis. This branch, for usually there is only one, is made up of broad, stout cells with rather unusually dark chromatophores. As the branch increases in length, it as a general rule becomes spirally twisted (cf. Figs. 12 to 14), and the cells grow out on the convex side into short branchlets (cf. Figs. 13 and 15). This frequently continues until a complex branch is produced. The terminal cell of the branch produces the procarp, which in *Tuomeya* consists of a broadly ovoid trichophore, surmounted by a trichogyne several times longer than itself. The trichogyne is a somewhat elongated lageniform body, about 30 μ high and 10 μ in diameter at the base, and is connected with the trichophore by a slender, elongated pedicel, which is often 10 μ long and 3 μ thick (cf. Figs. 16 to 20, *tr.*). Very frequently the trichogyne is attached to the pedicel obliquely (cf. Fig. 16). The contents of the trichogyne at maturity are clear, and of an extremely light bluish tint. When ready for fertilization, the trichogyne is usually very near to the surface of the frond in the older portions, but in the younger parts of looser structure it often remains very close to the axis.

One, two, or even three antherozoids may often be found attached near the tip of the trichogyne (cf. Figs. 18 and 19). An opening is made by the absorption of the intervening wall, and the contents of at least one of the antherozoids pass into the trichogyne. As a consequence of this, the trichophore, whose contents have already become granular in appearance, begins to put forth buds (cf. Figs. 17 to 19). These buds, which are at first few and comparatively large, gradually become divided into smaller and smaller lobes, until at last there is a considerable number of them arranged in more or less concentric rows upon the surface of the trichophore (cf. Fig. 20). As the cystocarp is thus developing, secondary branches grow toward it from the axis, and, surrounding it, obscure its farther development. As far as could be seen, strings of spores similar to those formed in *Batrachospermum* seemed to be produced.

In most of the species of *Batrachospermum,* especially in those which have a frond of loose structure, the procarp is borne at the apex of a short branch, which does not differ in any marked way from the other branches. In some of the denser species, however, this branch is somewhat modified. This is particularly striking in *B. densum*, Sirdt. (cf. Sirodot, Les Batrachospermes, Plate XIII. Figs. 6, 9, and 10), where the procarpic branch much resembles some of the simpler ones found in *Tuomeya.* This special branch in *B. densum* is by no means modified to the extent that the majority found in *Tuomeya* are. In *Lemanea* the procarpic branch is very different from any found in *Batrachospermum*, and seems more complicated in some ways than in *Tuomeya.* The procarpic branch in *Lemanea* arises from a cell placed against one of the lateral tubes. It is usually three or four cells long, and bears at the tip an elongated trichogyne which projects externally. The lower cells of this branch, in some species, (cf. Ketel, Anatomische Untersuchungen über die Gattung Lemanea, Inaug. Diss., Berlin, 1887,) produce a number of short branchlets similar to those in *Tuomeya.*

The trichogyne of *Tuomeya* is almost exactly like that of *Batrachospermum*, and yet in some of its various shapes it much resembles the trichogyne of certain of the simpler species of *Lemanea.* It is not, however, modified to any such extent as are the trichogynes of the ordinary *Lemaneæ.* The first stages in the formation of the cystocarp are also essentially like those of the cystocarp of *Batrachospermum.* Therefore, we may say that in the position and structure of the female organs, as well as in the development of the cystocarp, *Tuomeya* approaches certain of the more complex species of *Batrachospermum* on the one hand, and certain of the simpler forms of *Lemanea* on the other, thus occupying, in regard to these structures, an intermediate position between these two genera.

Harvey considered that a solid filamentous axis, coated externally with moniliform filaments, was characteristic of *Batrachospermum*, while *Lemanea* possessed a cylindrical and hollow frond, whose walls were laxly constructed within. *Tuomeya* seemed to him to possess the solid axis of a *Batrachospermum*, shut up within the tube of a *Lemanea*, and coated externally with the filaments of a *Thorea.* Harvey's idea of the relationship is a very good one. The solid axis, to be sure, more nearly resembles that of certain species of *Lemanea*, but in its earlier stages is almost exactly like that of *Batrachospermum.* The frond at one period is a hollow cylinder enclosing this axis, but it has developed like that of a true *Batrachospermum.* In its extreme later complex structure the frond surpasses anything of the kind found in either of the other two genera. In the structure of the antheridia, *Tuomeya* rather resembles *Batrachospermum*, but in the specialized antheridial branches and their position at the nodes, it comes very near to *Lemanea*. In the possession of a special procarpic branch, *Tuomeya* is like *Lemanea*, but in the development of the fruit it comes very near to *Batrachospermum*. All recent writers have agreed that *Lemanea* and *Batrachospermum* are nearly related, but *Tuomeya*, as may be seen from my comparison, brings them still nearer to one another. It may be a question as to which genus *Tuomeya* approaches most nearly, so very near does it approach to each of them.

It seems best to say a few words here in regard to a plant which has been referred to the genus *Tuomeya* as an additional species. In the Bulletin of the Torrey Botanical Club for 1877 (November), Rev. Francis Wolle describes a new species of alga, found by him at Bethlehem, Penn., which he makes the type of a new genus, under the name of *Entothrix grande*. Specimens were distributed in Rabenhorst's "Die Algen Europas," where by a misprint the name appears as *Entothrix grœdis*, n. sp., Wolle. In his "Fresh Water Algæ of the United States," (Bethlehem, 1887,) on pages 53 and 54, and Plate LXVI. Figs. 2 to 8, Mr. Wolle figures and describes this plant, and refers it to the genus *Tuomeya* as *T. grande*, Wolle, distinguished from *T. fluviatilis*, Harv., by its unbranched and tubular frond. I am indebted to Professor Farlow for the privilege of examining the specimens distributed by Rabenhorst, and Mr. Wolle has been so kind as to send me authentic specimens from his own herbarium. Careful sections from both sets of specimens show that this plant possesses the complicated axis, cortex, and lateral tubes characteristic of *Lemanea*, as limited by Sirodot, as well as the hollow frond and cystocarps of that genus. Professor George F. Atkinson of Auburn, Ala., has just published a preliminary note on the synonymy of this species (Bot. Gaz., XIV. 292), and has referred it to *Lemanea* as *L. grandis*, (Wolle) Atkinson. As far as is known, then, there is only one species of *Tuomeya*.*

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* I have very lately received, through the kindness of Professor Atkinson, a copy of the extra issue of his "Monograph of the Lemaneaceæ of the United States," which is to appear in the May number of the Annals of Botany. In this paper, Professor Atkinson gives a full description, with figures, of *Lemanea grandis*, (Wolle) Atk.

I wish, in conclusion, to express my gratitude to those who have aided me in my work, and especially to Professor Farlow and to Mr. Holden, to both of whom I am very greatly indebted.

Cryptogamic Laboratory,
Harvard University.

EXPLANATION OF FIGURES.

Fig. 1. A portion of a plant of *Tuomeya fluviatilis*, Harv., of the natural size, collected at Oxford, Conn., by Mr. Harger, Nov. 9, 1889.

Fig. 2. A portion of the very tip of a branch, showing the protruding filament with the young ramelli at its base. × 500.

Fig. 3. The protruding filament with the ramelli removed. × 375 × 2.

Fig. 4. Cross-section through the protruding filament about 40 μ from tip. × 375 × 2.

Fig. 5. Portion of a young branch, with ramelli removed by crushing, showing a young branchlet. × 375 × 2.

Fig. 6. Young portion of a branch, showing the axis and two ramelli. The other ramelli have been removed by crushing. About .25 mm. from the tip. × 375.

Fig. 7. A portion of a young branch, showing one ramellus with young secondary filaments just starting forth. × 375.

Fig. 8. Older specimen, showing the origin of the secondary filaments. × 375.

Fig. 9. Older portion, with some of the ramelli removed by crushing, showing a more advanced stage of the ramelli and of the secondary filaments. × 375.

Fig. 10. Cross-section of an adult, solid stem.
a, axial cell.
b, bundle of secondary filaments.
c, inner portions of ramelli.
d, outer " "
e, coat of moniliform filaments. × 312.

Fig. 11. Showing an adventitious branch. × 375.

Fig. 12. Showing a very young procarpic branch. × 500.

Fig. 13. Young procarpic branch producing branchlets on the convex side. × 500.

Fig. 14. Young procarpic branch, which has become decidedly spirally twisted. × 500.

Fig. 15. Procarpic branch with trichogyne (*tr.*). The branchlets have been mostly removed in crushing. × 500.

Fig. 16. Showing a trichogyne attached obliquely to the pedicel. × 385.

Fig. 17. Trichogyne with antherozoid attached and with trichophore budding. × 385.

Fig. 18. Showing the same points, but farther advanced. × 385.

Fig. 19. Trichogyne with two antherozoids attached and with the trichophore budding. × 385.

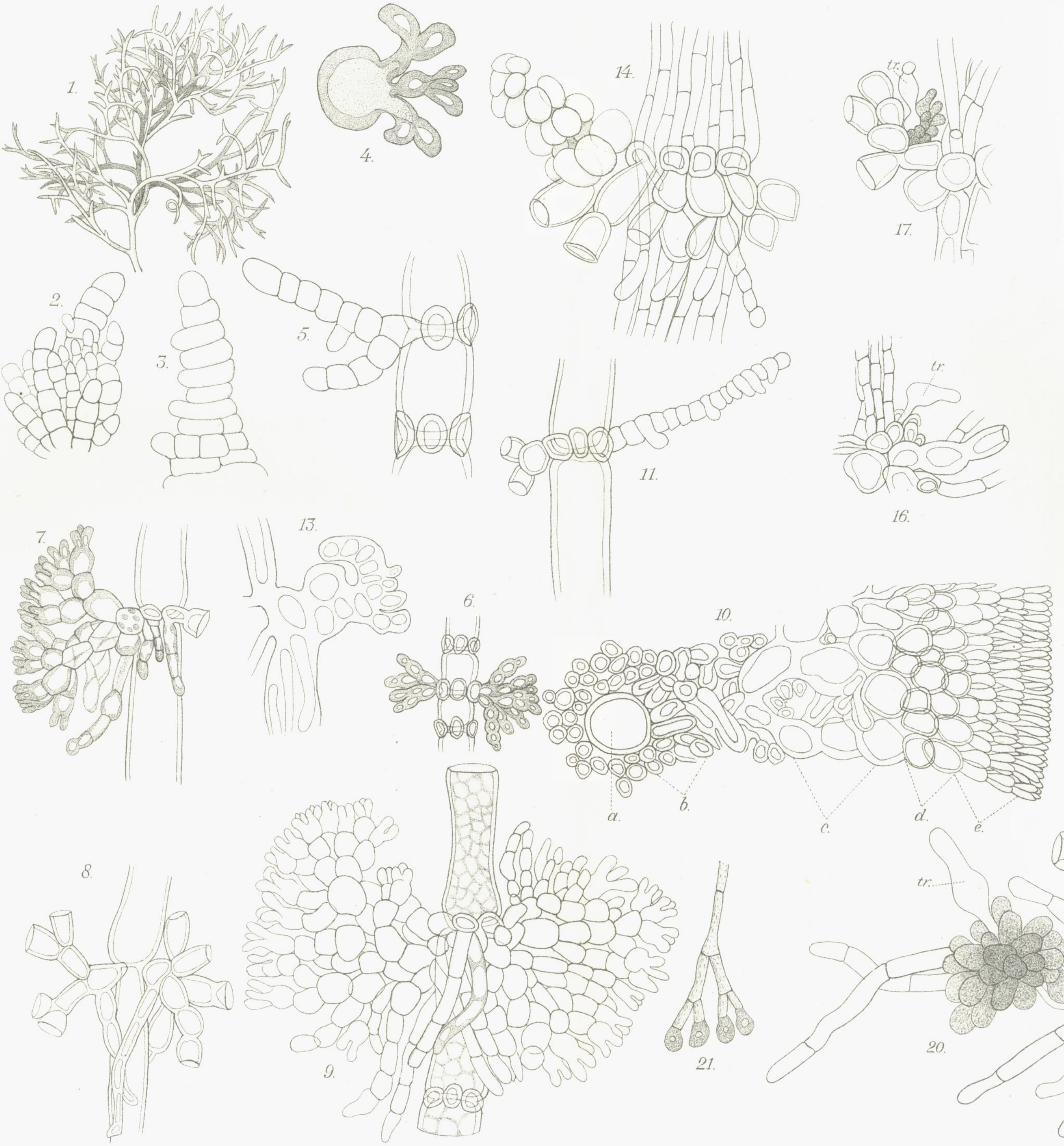
Fig. 20. Young cystocarp. × 500.

Fig. 21. Extremity of an antheridial branch with antheridia. × 385.

Fig. 22. Portion of a cluster of antheridial branches, seen in longitudinal section. × 500.

Figure 1 was drawn by Mr. William D. Denton from a living plant; the rest of the figures were drawn by the author, with the aid of the camera lucida.

SETCHELL — TUOMEYA FLUVIATILIS.



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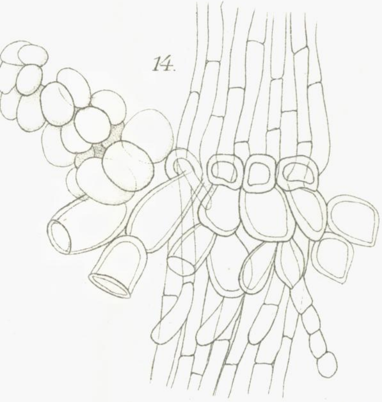
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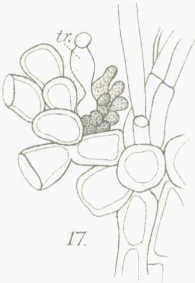
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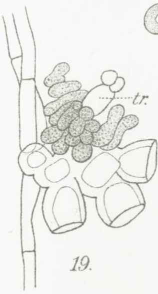
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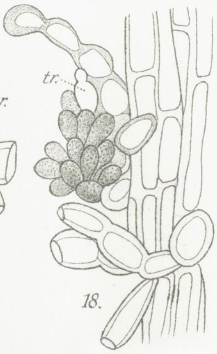
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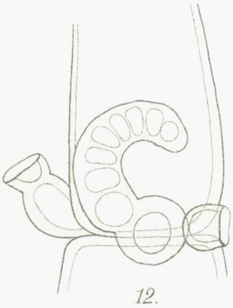
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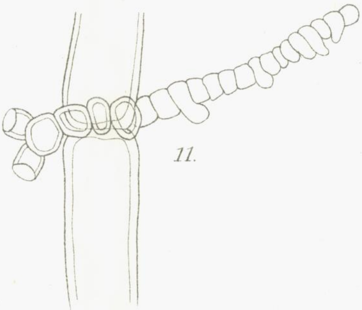
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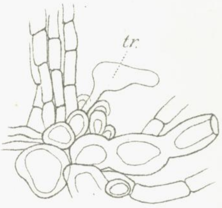
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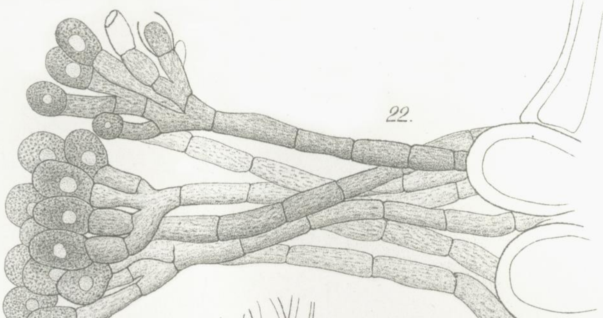
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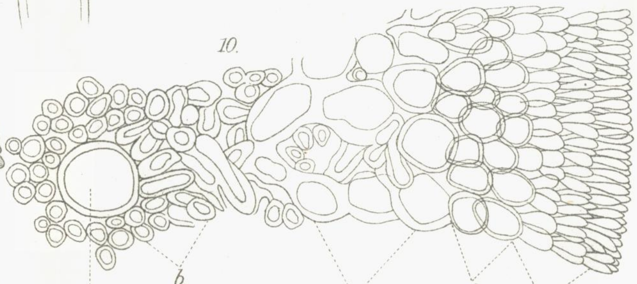
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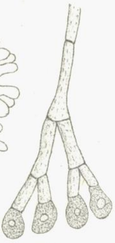
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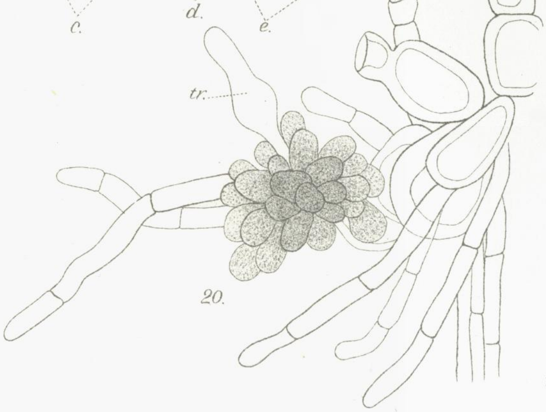
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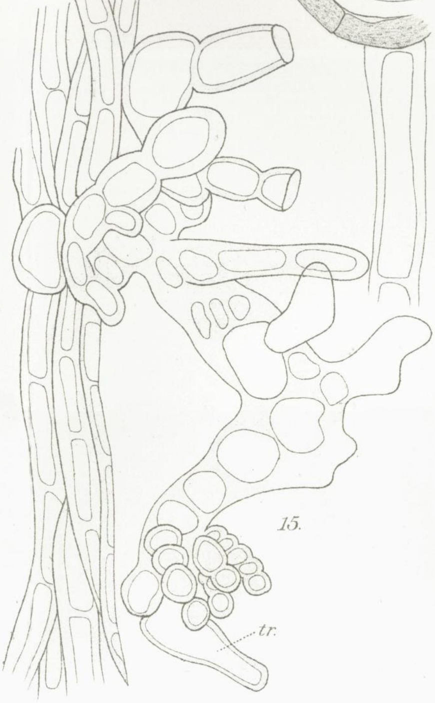
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B. Meisel, lith. Boston.